(12) United States Patent
Wang et al.

(10) **Patent No.: US 9,140,578 B2**
(45) **Date of Patent: Sep. 22, 2015**

(54) **MEASUREMENT DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 359 days.

(21) Appl. No.: **13/869,597**

(22) Filed: **Apr. 24, 2013**

(65) **Prior Publication Data**

US 2014/0159708 A1 Jun. 12, 2014

(30) **Foreign Application Priority Data**

Dec. 6, 2012 (TW) .... 101145944 A

(51) **Int. Cl.**
G01B 7/14 (2006.01)
G01D 5/20 (2006.01)
G01D 5/22 (2006.01)

(52) **U.S. Cl.**
CPC ... ***G01D 5/20*** (2013.01); ***G01D 5/22*** (2013.01)

(58) **Field of Classification Search**
USPC 324/207.16, 207.17, 207.18, 207.19
See application file for complete search history.

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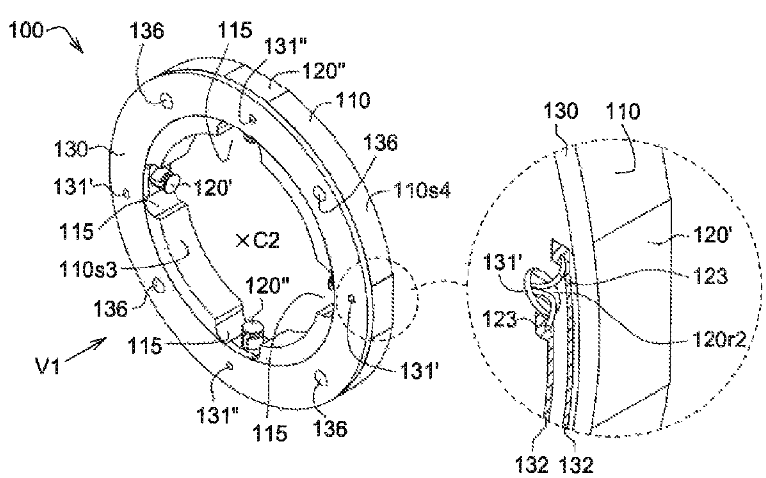
(57) **ABSTRACT**

A measurement device is provided. The measurement device comprises a ring-shaped base and multiple sensing elements. The sensing elements are symmetrically disposed on the ring-shaped base. Each sensing element comprises a circumferential groove, an axial groove and a coil. The axial groove is connected to the circumferential groove. The coil is surrounded within the circumferential groove and extended along the axial groove.

14 Claims, 2 Drawing Sheets



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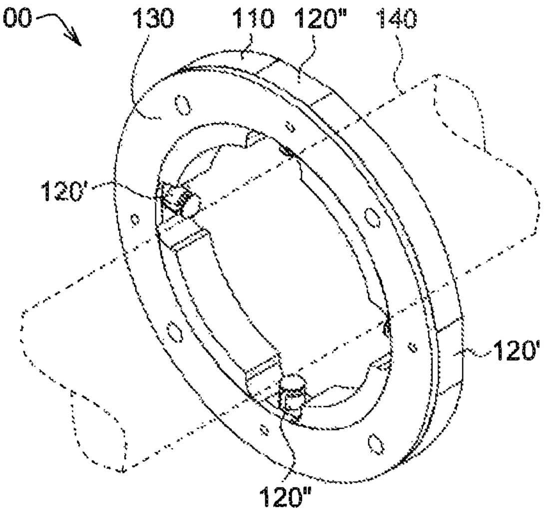
100
130
110
120"
140
120'
120'
120"

FIG. 1

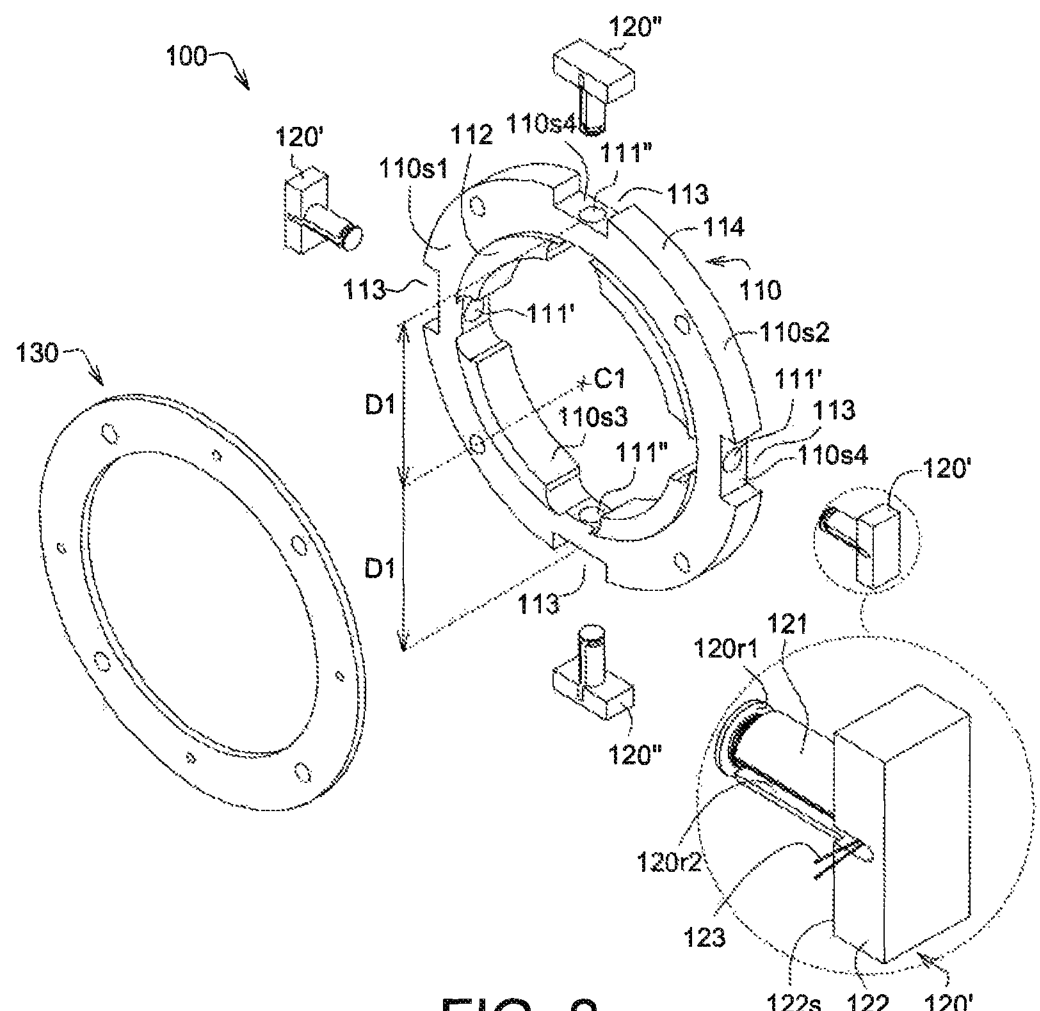
100
120"
120'
112
110s4
110s1
111"
113
114
113
110
111'
110s2
130
C1
111'
D1
110s3
113
111"
110s4
120'
D1
113
121
120r1
120"
120r2
123
122s
122
120'

FIG. 2

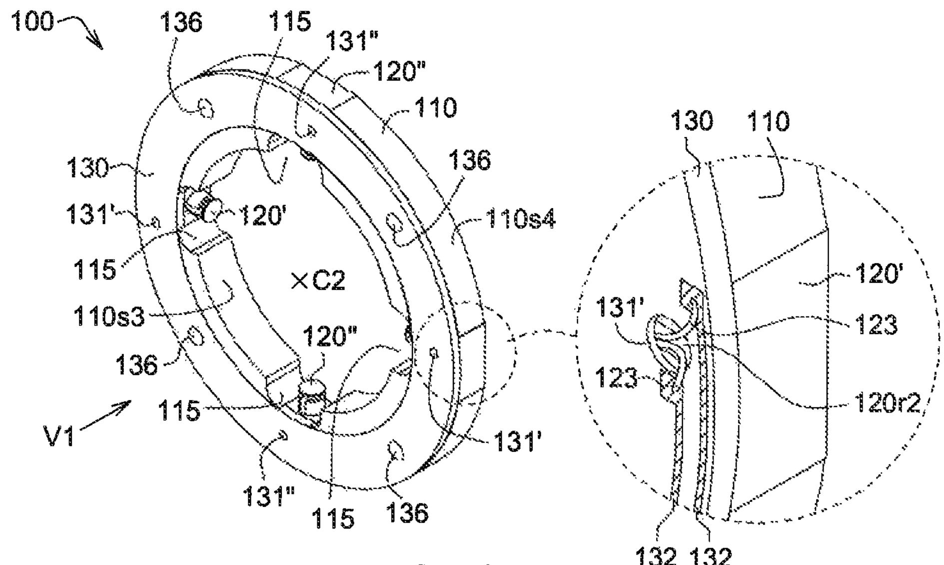
100
136
115
131"
120"
110
130
136
131'
120'
110s4
115
C2
110s3
120"
136
115
V1
131'
131"
115
136
130
110
120'
131'
123
123
120r2
132
132

FIG. 3

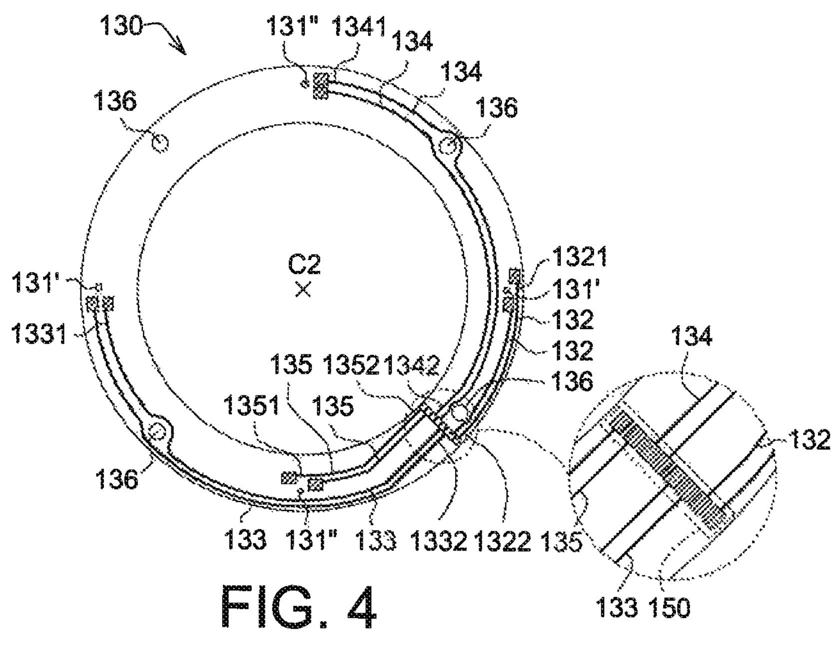
130
131"
1341
134
134
136
136
C2
1321
131'
131'
132
1331
132
135
1352
1342
136
1351
135
134
132
136
133
131"
133
1332
1322
135
133
150

FIG. 4

MEASUREMENT DEVICE

This application claims the benefit of Taiwan application Serial No. 101145944, filed Dec. 6, 2012, the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

The disclosure relates in general to a measurement device, and more particularly to a measurement device having multiple sensing elements.

BACKGROUND

Non-contact displacement sensor is a crucial element in the industrial rotor measurement system. Most displacement sensors are fixed on a base by screws. However, such assembly method often has large assembly error and leads to a decrease in measurement precision.

SUMMARY

The disclosure is directed to a measurement device.

According to one embodiment, a measurement device is provided. The measurement device comprises a ring-shaped base and a plurality of sensing elements. The sensing elements are symmetrically disposed on the ring-shaped base, and each sensing element comprises a circumferential groove, an axial groove and a coil. The axial groove is connected to the circumferential groove. The coil is surrounded within the circumferential groove and passes through the axial groove go out of the axial groove.

The above and other aspects of the disclosure will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment(s). The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an assembly diagram of a measurement device according to an embodiment of the disclosure;

FIG. **2** shows an explosion diagram of a measurement device of FIG. **1**;

FIG. **3** shows an assembly diagram of a ring-shaped base and multiple sensing elements of FIG. **1**;

FIG. **4** shows a lateral view of a ring-shaped circuit board viewed along a direction V**1** of FIG. **3**.

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

DETAILED DESCRIPTION

Referring to FIG. **1**, an assembly diagram of a measurement device according to an embodiment of the disclosure is shown. The measurement device **100** comprises a ring-shaped base **110**, two symmetrical sensing elements **120'**, another two symmetrical sensing elements **120"** and a ring-shaped circuit board **130**. A shaft **140** passes through the ring-shaped base **110**. When the shaft **140** rotates, the sensing elements **120'** and **120"** can measure displacement in two radial directions of the shaft **140** respectively.

Referring to FIG. **2**, an explosion diagram of a measurement device of FIG. **1** is shown. The ring-shaped base **110** has four assembly holes **111'** and **111"**, each of the assembly holes **111'** and **111"** radially penetrates the ring-shaped base **110**. The quantity of assembly holes **111'** and **111"** is the same as that of the sensing elements **120'** and **120"**. The sensing element **120'** is inserted into the assembly hole **111'**, and the sensing element **120"** is inserted into the assembly hole **111"**. Two assembly holes **111'** are symmetrically formed on the ring-shaped base **110**, such that the sensing elements **120'** inserted therein are also disposed in a symmetrical manner. Another two assembly holes **111"** are symmetrically formed on the ring-shaped base **110**, such that the sensing elements **120"** inserted therein are also disposed in a symmetrical manner. In the present embodiment, the two sensing elements **120'** can measure displacement in one of the radial dimension of the shaft **140**, and another two sensing elements **120"** can measure displacement in the other one of the radial dimension of the shaft **140**.

In the present embodiment, the quantity of sensing elements of the measurement device **100** is exemplified by two pairs. In another embodiment, the quantity of sensing elements can be one pair for measuring displacement in one single radial dimension of the shaft **140**. In another embodiment, the quantity of sensing elements can be two or more than two pairs for measuring displacement in two radial dimensions of the shaft **140**.

Two neighboring sensing elements **120'** and **120"** form an angle of 90 degrees with respect to the geometric center C**1**, such that the connecting line between two symmetrically sensing elements **120'** is perpendicular to that between another two symmetrical sensing elements **120"** for measuring displacement in two orthogonal radial directions of the shaft **140** (illustrated in FIG. **1**).

Two symmetrically sensing elements **120'** form one pair of differential sensing elements, and another two symmetrical sensing elements **120"** form another pair of differential sensing elements, such that the influence on the sensing elements by temperature drift can be eliminated. In an embodiment, the sensing elements **120** and **120"** are eddy-current sensing probe with high precision, high bandwidth and property impervious to surface cleanliness.

The ring-shaped base **110** comprises a radial surface **110*s*1**, a protruding portion **112** and a ring-shaped body **114**. The protruding portion **112** is disposed on the ring-shaped body **114** and projects from the radial surface **110*s*1**, such that the ring-shaped circuit board **130** can be engaged with the outer edge of a side of the protruding portion **112**.

The ring-shaped base **110** further has an outer circumferential surface **110*s*2**, an inner circumferential surface **110*s*3** opposite to the outer circumferential surface **110*s*2** and four outer recesses **113**. Each outer recess **113** is extended towards the inner circumferential surface **110*s*3** from the outer circumferential surface **110*s*2** without penetrating the ring-shaped base **110**. Each of the sensing elements **120'** and **120"** is disposed in the corresponding outer recess **113**. The sensing elements **120'** and **120"** can be tightly disposed in at least one of the outer recess **113** and the assembly hole (**111'** and **111"**). For example, the sensing elements **120'** and **120"** can all be disposed in the outer recess **113** or the assembly holes **111'** and **111"**. Alternatively, a part of the sensing elements **120'** and **120"** can be disposed in the outer recess **113**, and another part can be disposed in the assembly hole **111'** and/or **111"**. The present embodiment of the disclosure does not restrict the disposition of the sensing elements and any disposition would do as long as the two sensing elements **120'** are disposed in a symmetric manner and another two sensing elements **120"** are also disposed in a symmetric manner.

As indicated in FIG. **2**, each of the sensing elements **120'** and **120"** comprises a stud **121** and a positioning portion **122**, wherein the stud **121** is inserted into the corresponding assembly hole (**111'** and **111"**). The positioning portion **122** is connected to the stud **121** and has a positioning surface **122***s*. The ring-shaped base **110** has a positioning surface **110***s***4**. The assembly holes **111'** and **111"** penetrate the ring-shaped base **110** from the positioning surface **110***s***4** of the ring-shaped base **110**. The positioning portion **122** is positioned on the positioning surface **110***s***4** of the ring-shaped base **110** by the positioning surface **122***s*. In the present embodiment, the positioning surface **122***s* of the positioning portion **122** fits the positioning surface **110***s***4** of the ring-shaped base **110**. In another embodiment, the positioning surface **122***s* and the positioning surface **110***s***4** are curved surfaces matching each other.

The disposition positions of the sensing elements **120'** and **120"** are determined according to the distance D1 from the positioning surface **110***s***4** of the ring-shaped base **110** to the geometric center C1 of the ring-shaped base **110**. In the present embodiment, the distance D1 from each positioning surface **110***s***4** of the ring-shaped base **110** to the geometric center C1 of the ring-shaped base **110** is substantially the same, such that the measurement precision of the sensing elements **120'** and **120"** can be increased.

Each of the sensing elements **120'** and **120"** has a circumferential groove **120***r***1**, an axial groove **120***r***2** and a coil **123**. The coil **123** is surrounded within the circumferential groove **120***r***1**, and is extended along and passes through the axial groove **120***r***2**. The circumferential groove **120***r***1** is formed at one end of the stud **121**, and the axial groove **120***r***2** is extended to the positioning portion **122** from the circumferential groove **120***r***1**, such that after the sensing elements **120'** is disposed within the assembly hole **111'**, the sensing elements **120"** is disposed within the assembly hole **111"**, and the axial groove **120***r***2** can be exposed outside the ring-shaped base **110** as indicated in FIG. **3**.

Referring to FIG. **3**, an assembly diagram of a ring-shaped base and multiple sensing elements of FIG. **1** is shown. After the sensing elements **120'** is disposed in the assembly hole **111'** and the sensing elements **120"** is disposed in the assembly hole **111"**, the axial groove **120***r***2** is exposed outside the ring-shaped base **110**. After the coil **123** passes through the exposed axial groove **120***r***2**, the coil **123** is electrically connected to the ring-shaped circuit board **130**.

The ring-shaped base **110** further has four inner recesses **115**. Each inner recess **115** is extended towards the outer circumferential surface **110***s***4** from the inner circumferential surface **110***s***3** without penetrating the ring-shaped base **110**. After the sensing elements **120'** is disposed in the assembly hole **111'** and the sensing elements **120"** is disposed in the assembly hole **111"**, one end of each of the sensing elements **120'** and **120"** is disposed in the corresponding inner recess **115**. The inner recesses **115** provides an isolation space, which avoids the coil **123** within the circumferential groove **120***r***1** of each of the sensing elements **120'** and **120"** being too close to the ring-shaped base **110** and affecting the distribution of the magnetic field generated by the coil **123**.

In the present embodiment, the ring-shaped circuit board **130** has two outlet holes **131'** and another two outlet holes **131"**. The two outlet holes **131'** are symmetrically distributed with respect to the geometric center C2 of the ring-shaped circuit board **130**, and another two outlet holes **131"** are symmetrically distributed with respect to the geometric center C2 of the ring-shaped circuit board **130**. After the ring-shaped circuit board **130** is disposed on the ring-shaped base **110**, the two outlet holes **131'** correspond to two sensing elements **120'** and another two outlet holes **131"** correspond to two sensing elements **120"**, such that the coil **123** surrounding the sensing elements **120'** and **120"** is exposed from the corresponding outlet hole **131'** and **131"** nearby and connected to the ring-shaped circuit board **130**. After each coil **123** is exposed from the corresponding axial groove **120***r***2**, the coil **123** passes through the corresponding outlet hole **131'** or **131"** and is electrically connected to the ring-shaped circuit board **130**. Also, the ring-shaped circuit board **130** has four screw holes **136** through which the screws pass for locking the ring-shaped circuit board **130** on the ring-shaped base **110**.

Referring to both FIG. **3** and FIG. **4**. FIG. **4** shows a lateral view of a ring-shaped circuit board viewed along a direction V1 of FIG. **3**. The ring-shaped circuit board **130** comprises two first traces **132** and two second traces **133**. One end **1321** of each first trace **132** is adjacent to one of the outlet holes **131**, and one end **1331** of each second trace **133** is adjacent to the other one of the outlet holes **131'**. The other end **1322** of each first trace **132** is adjacent to the other end **1332** of each second trace **133**. Similarly, the ring-shaped circuit board **130** further comprises two third traces **134** and two fourth traces **135**. One end **1341** of each third trace **134** is adjacent to one of the outlet holes **131"**, and one end **1351** of each fourth trace **135** is adjacent to the other one of the outlet holes **131"**. The other end **1342** of each third trace **134** is adjacent to the other end **1352** of each fourth trace **135**. In the present embodiment, the other end **1322** of the first trace **132**, the other end **1332** of the second trace **133**, the other end **1342** of the third trace **134** and the other end **1352** of the fourth trace **135** are adjacent to each other (in a centralized manner), such that the same electrical connection piece **150** can be connected to the terminal points of all traces at one time. In comparison to the distributed distribution of traces, the design of centralized distribution of the present embodiment of the disclosure enables the electrical connection piece **150** to be connected to the terminal points of all traces by a smaller area. Here, the electrical connection piece is such as a flexible circuit board or other suitable electrical connection piece.

The quantities of sensing elements (**120'** and **120"**), outer recesses **113**, inner recesses **115** and assembly hole (**111'** and **111"**) are all exemplified by four pieces. In another embodiment, the quantities of sensing elements (**120'** and **120"**), outer recesses **113**, inner recesses **115** and assembly holes (**111'** and **111"**) can all be smaller or larger than four pieces, and are not limited to even numbers.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments. It is intended that the specification and embodiments be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. A measurement device, comprising:
- a ring-shaped base comprising a plurality of assembly holes symmetrically arranged around a circumferential surface of the ring-shaped base; and
- a plurality of sensing elements, wherein each sensing element comprises:
  - a stud comprising a circumferential groove formed at a first end of the stud and
  - an axial groove connected to the circumferential groove and extending to a second end of the stud opposite the first end of the stud; and

a coil wound within the circumferential groove and having coil leads passing through the axial groove to go out of the axial groove at the second end of the stud;

wherein each stud is inserted into a corresponding one of the assembly holes of the ring-shaped base.

2. The measurement device according to claim **1**, wherein each sensing element comprises a positioning portion connected to the second end of the stud and having a positioning surface for positioning the positioning portion on the ring-shaped base.

3. The measurement device according to claim **2**, wherein each positioning surface is a plane or a curved surface.

4. The measurement device according to claim **1**, wherein the ring-shaped base has a plurality of positioning surfaces, each assembly hole penetrating the ring-shaped base through a corresponding one of the positioning surfaces.

5. The measurement device according to claim **4**, wherein any of the positioning surface of the positioning portion and the positioning surface of the ring-shaped base is a plane or a curved surface.

6. The measurement device according to claim **4**, wherein a distance from each positioning surface of the ring-shaped base to a geometric center of the ring-shaped base is substantially the same.

7. The measurement device according to claim **2**, wherein each axial groove is extended to the positioning portion from the circumferential groove and exposed outside the ring-shaped base, and the coil leads pass through the exposed axial grooves.

8. The measurement device according to claim **1**, further comprising:

a ring-shaped circuit board disposed on the ring-shaped base.

9. The measurement device according to claim **8**, wherein the ring-shaped circuit board has a plurality of outlet holes,

and the coil leads of each coil pass through a corresponding one of the outlet holes and are electrically connected to the ring-shaped circuit board.

10. The measurement device according to claim **9**, wherein the ring-shaped circuit board comprises two first traces and two second traces, one end of each first trace is adjacent to one of the outlet holes, one end of each second trace is adjacent to another one of the outlet holes, and the other end of each first trace is disposed adjacent to the other end of each second trace.

11. The measurement device according to claim **8**, wherein the ring-shaped base comprises a radial surface and a protruding portion projecting from the radial surface, and the ring-shaped circuit board is engaged with the protruding portion.

12. The measurement device according to claim **1**, wherein the ring-shaped base has an outer circumferential surface, an inner circumferential surface and a plurality of outer recesses, each outer recess is extended towards the inner circumferential surface from the outer circumferential surface without penetrating the ring-shaped base, and one end of each sensing element is disposed within a corresponding one of the outer recesses.

13. The measurement device according to claim **1**, wherein the ring-shaped base has an outer circumferential surface, an inner circumferential surface and a plurality of inner recesses, each inner recess is extended towards the outer circumferential surface from the inner circumferential surface without penetrating the ring-shaped base, and one end of each sensing element is located within a corresponding one of the inner recesses.

14. The measurement device according to claim **1**, wherein two of the sensing elements are symmetrically disposed on the ring-shaped based relative to each other, and another two of the sensing elements are symmetrically disposed on the ring-shaped based relative to each other.

* * * * *